

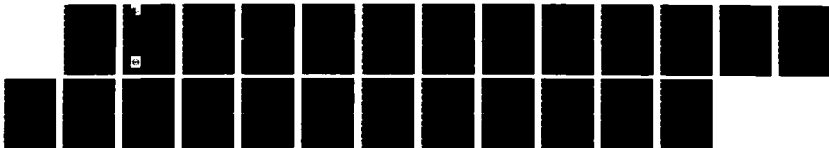
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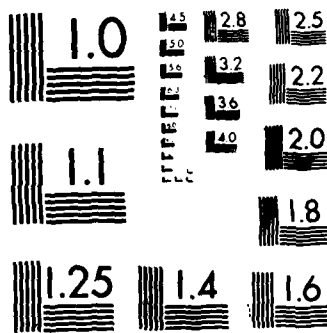
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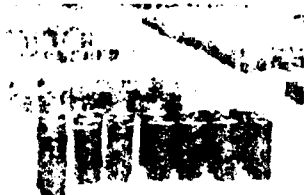
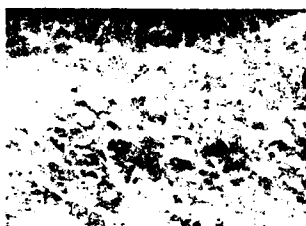


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TECHNICAL REPORT EL 86-27

SWITCHGRASS (*Panicum virgatum*)

Section 7.1.2, US ARMY CORPS OF ENGINEERS  
WILDLIFE RESOURCES MANAGEMENT MANUAL

by

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19 ABSTRACT (Continue on reverse if necessary and identify by block number) A plant materials report on switchgrass ( <i>Panicum virgatum</i> ) is provided as Section 7.1.2 of the US Army Corps of Engineers Wildlife Resources Management Manual. The report was prepared as a guide to assist the Corps District or project biologist with the selection, cultivation, and management of suitable plant materials for wildlife and habitat development programs. Topics covered include description, distribution, habitat requirements, wildlife value, establishment, maintenance, and cautions and limitations.  Switchgrass is a native, perennial, warm-season bunchgrass and is a major component of the Midwestern tallgrass prairie. The seeds, foliage, and stiff upright stems provide food and cover for a variety of wildlife species. Distinguishing characteristics of switchgrass are described, and the species distribution and region of maximum abundance are given. Soil, moisture, and shade requirements are specified, and common plant associates in tall-grass prairies are listed. Food and cover value for several species of wildlife is - (Continued)					
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discussed. The section on establishment provides guidelines for site selection, site preparation, propagule selection, and planting methods. Recommended planting mixtures are given for several regions. Maintenance requirements and cautions and limitations are discussed.



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## PREFACE

This work was sponsored by the Office, Chief of Engineers (OCE), US Army, as part of the Environmental Impact Research Program (EIRP), Work Unit 31631, entitled Management of Corps Lands for Wildlife Resource Improvement. The Technical Monitors for the study were Dr. John Bushman and Mr. Earl Eiker, OCE, and Mr. Dave Mathis, Water Resources Support Center.

This report was prepared by Mr. Clinton H. Wasser, Professor Emeritus, Range Science Department, Colorado State University, Fort Collins, Colo.; Dr. Phillip L. Dittberner, US Fish and Wildlife Service, Western Energy and Land Use Team (WELUT), Fort Collins, Colo.; and Dr. Wilma A. Mitchell, Wetlands and Terrestrial Habitat Group (WTHG), Environmental Laboratory (EL), US Army Engineer Waterways Experiment Station (WES). Mr. Chester O. Martin, Team Leader, Wildlife Resources Team, WTHG, was principal investigator for the work unit. The original report was prepared by WELUT under an Interagency Agreement with WES. Ms. Cathy Short and Ms. Pam Hutton, WELUT, assisted with manuscript preparation. Review and comments were provided by Mr. Martin, WTHG, and Mr. Larry E. Marcy, Texas A&M University.

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#### NOTE TO READER

This report is designated as Section 7.1.2 in Chapter 7 -- PLANT MATERIALS, Part 7.1 -- GRASSES, of the US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL. Each section of the manual is published as a separate Technical Report but is designed for use as a unit of the manual. For best retrieval, this report should be filed according to section number within Chapter 7.



## SWITCHGRASS (*Panicum virgatum*)

### Section 7.1.2, US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL

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Switchgrass is a native, perennial, warm-season bunchgrass and a major component of the Midwestern tallgrass prairie. It is used predominantly in the southern Great Plains and Prairie States for hay, pasture forage, soil and water conservation, mine soil stabilization, and range improvement. The seeds, abundant foliage, and stiff upright stems provide food and protective cover for a variety of wildlife species.

#### DESCRIPTION

Switchgrass has coarse erect culms that are from 2 to 5 ft (0.6 to 1.5 m) tall (Fig. 1). Its dense fibrous roots are reinforced by a mat of stout, scaly rhizomes that enable the species to form soil-binding colonies (USDA Forest Service 1937). The scabrous leaves vary from blue to blue-green, may be flat or folded, and grow to 2 ft (0.6 m) in length and 0.5 in. (2.5 cm) in width (Vallentine 1967, Coastal Zone Resources Division 1978). A short hairy ligule covers long hairs at the base of each leaf blade, and pubescence occurs on the blade sheath and along leaf margins.

The seedhead is an open spreading panicle, 6 to 20 in. (15 to 50 cm) long, that bears numerous oval, pointed spikelets at the tips of inflorescence branches. Each spikelet contains 2 florets. The lower floret is sterile and

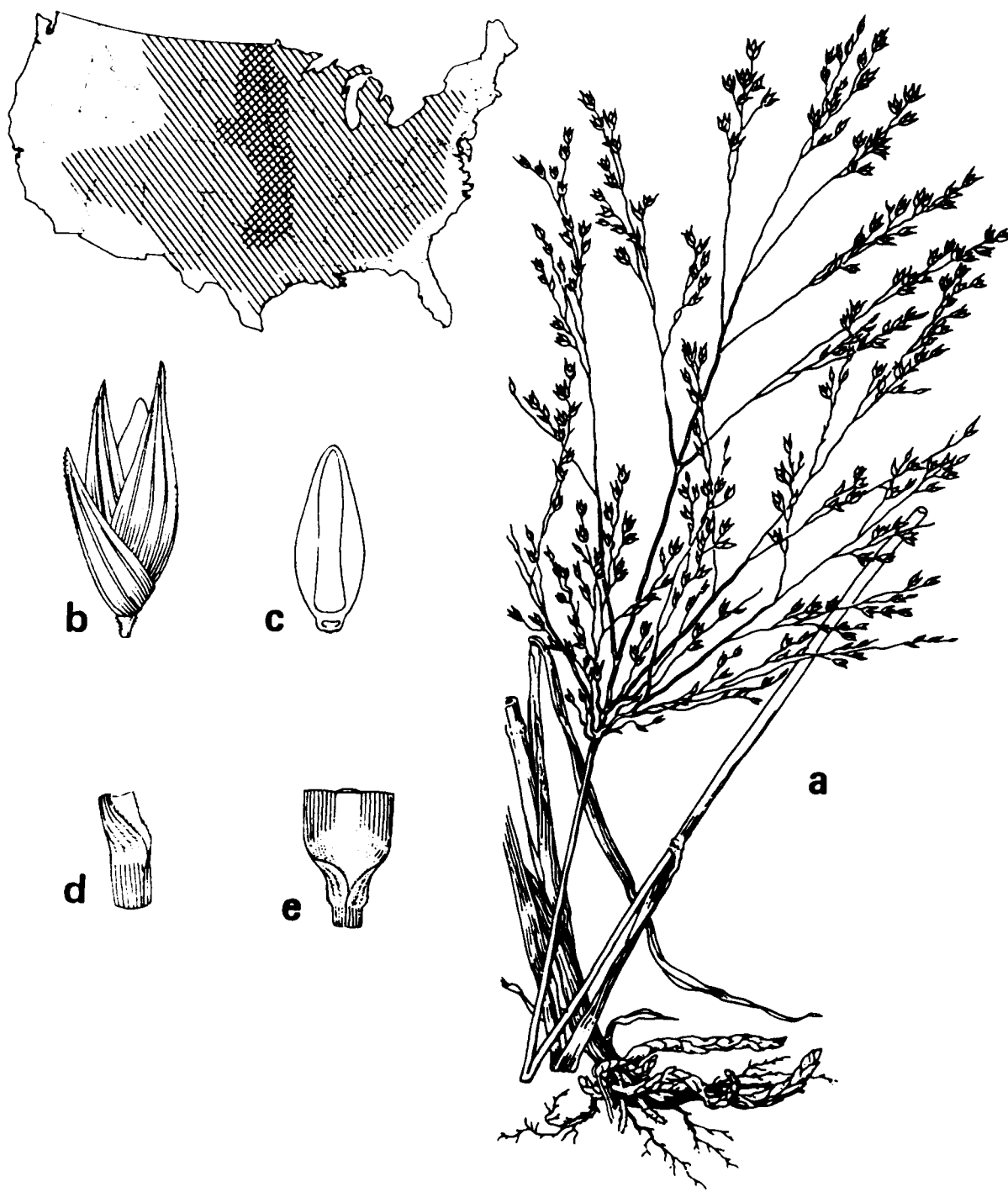


Figure 1. Distribution and distinguishing characteristics of switchgrass (*Panicum virgatum*): (a) entire plant, (b) spikelet, (c) floret, (d) collar, and (e) ligule. The map shows the species distribution (diagonal lines) and region of maximum abundance (crosshatching)

bract-like, and the smooth upper one is fertile and fused to the flattened grayish seed (Vallentine 1967, Cronquist et al. 1977). Plants resume growth in midspring, flowering occurs from late spring through midsummer, and seeds mature in late summer and fall (Hoover et al. 1947, Atkins and Smith 1967, Wasser 1982).

#### DISTRIBUTION

Switchgrass occurs throughout the conterminous United States except in California and the Pacific Northwest (Fig. 1). The center of maximum abundance and utilization encompasses the prairies and sandhills extending from eastern North Dakota and western Wisconsin to east Texas (Atkins and Smith 1967). The species is also widely used in the central and southern Great Plains, at higher elevations of the Southwest, and on mine spoils of Eastern coal fields (Hull et al. 1958; McIlvain and Shoop 1960a,b; Merkel and Herbel 1973; Vogel 1981). Switchgrass grows from sea level to elevations of 7800 ft (Harrington 1964, Wasser 1982) and is recommended for seeding up to 9000 ft in New Mexico (Merkel and Herbel 1973).

#### HABITAT REQUIREMENTS

Switchgrass commonly occurs on moist, or seasonally moist, open sites such as fresh or brackish marshes, lake and pond margins, wet prairies and savannas, swales, seepage areas, irrigation ditches, and roadside borrow pits (Correll and Correll 1972, Cronquist et al. 1977, Coastal Zone Resources Division 1978). Kuchler (1964) identified switchgrass as a component of the 6 potential vegetation types listed below (dominant plant genera are shown in parentheses). Common plant associates of switchgrass in tallgrass prairies are listed in Table 1.

Mesquite - Live Oak Savanna (*Prosopis* - *Quercus* - *Andropogon*)

Sandsage - Bluestem Prairie (*Artemisia* - *Andropogon*)

Nebraska Sandhills Prairie (*Andropogon* - *Calamovilfa*)

Blackland Prairie (*Andropogon* - *Stipa*)

Southern Cordgrass Prairie (*Spartina*)

Cross Timbers (*Quercus* - *Andropogon*)

Table 1. Common associates of switchgrass in native Midwestern tallgrass prairies (Weaver and Fitzpatrick 1934)

---

Grasses

Redtop	<i>Agrostis alba</i> = <i>A. stolonifera</i>
Big bluestem	<i>Andropogon gerardii</i>
Sand bluestem	<i>A. hallii</i> = <i>A. gerardii hallii</i>
Sideoats grama	<i>Bouteloua curtipendula</i>
Blue grama	<i>B. gracilis</i>
Hairy grama	<i>B. hirsuta</i>
Prairie sandreed	<i>Calamovilfa longifolia</i>
Inland saltgrass	<i>Distichlis spicata stricta</i>
Canada wildrye	<i>Elymus canadensis</i>
Carolina lovegrass	<i>Eragrostis pectinacea</i>
Junegrass	<i>Koeleria cristata</i>
Marsh muhly	<i>Muhlenbergia racemosa</i>
Scribner panicgrass	<i>Panicum scribnerianum</i>
Wilcox panicgrass	<i>P. wilcoxianum</i>
Kentucky bluegrass	<i>Poa pratensis</i>
Little bluestem	<i>Schizachyrium scoparium</i>
Indiangrass	<i>Sorghastrum nutans</i>
Prairie cordgrass	<i>Spartina pectinata</i>
Tall dropseed	<i>Sporobolus asper</i>
Prairie dropseed	<i>S. heterolepis</i>
Eastern gammagrass	<i>Tripsacum dactyloides</i>

Sedges and Rushes

Straw sedge	<i>Carex brevior</i>
Fox sedge	<i>C. vulpinoidea</i>
Slender rush	<i>Juncus tenuis</i>

Forbs\*

Whorled milkweed	<i>Asclepia verticillata</i>
Arrow aster	<i>Aster salicifolius</i>
Sawtooth sunflower	<i>Helianthus grosseserratus</i>
Smooth horsetail	<i>Equisetum laevigatum</i>
Tall goldenrod	<i>Solidago rupestris</i>

---

\* Only species occurring in 75% of samples are included.

### Soils

Switchgrass occurs on a variety of soils with textures ranging from sands to clays (Derscheid et al. 1977). It is most productive on fertile, loamy to clayey floodplain soils; however, stands are common on loose, sandy soils of the Central States (USDA Forest Service 1937). The species is tolerant of moderate salinity but will not grow on sodic soils. Plants are best suited to soils with a pH of 5.0 to 7.6 (Coastal Zone Resources Division 1978) and will tolerate those with a pH of 4.0 (Vogel 1981). With the application of nitrogen, switchgrass can produce good cover on eroded and relatively infertile land (Derscheid et al. 1977).

### Moisture

Switchgrass requires 16 to 18 in. mean annual precipitation with the majority of rainfall occurring in the growing season. In areas with less than 18 in. of precipitation, plants produce well when growing in deep sands, areas of water accumulation, or cooler climates of the western High Plains and Southwest (Hull et al. 1958, Vallentine 1967, Merkel and Herbel 1973, Thornburg 1982). Switchgrass is tolerant of poor soil drainage, subirrigation, and flooding but can tolerate no more than 20 days of inundation (Vallentine 1967, Derscheid et al. 1977, Vogel 1981). The species is fairly drought resistant; it declines greatly in production and cover quality during droughts but rarely dies out completely (Weaver and Albertson 1956).

### Shade

Switchgrass grows best in full sunlight but is moderately shade tolerant. It is found in open woodlands, shrublands, and dense meadow stands with taller grasses (Wasser 1982). Tolerance to shade renders the species potentially important for grazing under young pines and in stands that have been thinned several times (Grelen and Duvall 1966).

## WILDLIFE VALUE

Seeds of *Panicum* species are important food sources for ground-feeding birds in the United States (Martin et al. 1951). Davison (1967) rated switchgrass as a choice food for the northern bobwhite (*Colinus virginianus*), mourning dove (*Zenaida macroura*), northern cardinal (*Cardinalis cardinalis*), brown-headed cowbird (*Molothrus ater*), dark-eyed junco (*Junco hyemalis*), field

sparrow (*Spizella pusilla*), American tree sparrow (*S. arborea*), and white-throated sparrow (*Zonotrichia albicollis*). Switchgrass has been found in the diets of gadwall's (*Anas strepera*) in Louisiana (Paulus 1982), and its food value has been rated as good for waterfowl in several Western States (Dittberner and Olson 1983).

Switchgrass is potentially valuable for a much wider range of birds and for some mammals. Johnson and Anderson (1980) reported the use of switchgrass windbreaks by birds and small mammals. Dittberner and Olson (1983) rated it as generally good food and cover for birds and small mammals but as poor to fair forage and cover for elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), and pronghorn (*Antilocapra americana*) (Table 2).

Switchgrass provides habitat for upland game birds that utilize tall grasses for cover. Stands of Blackwell switchgrass (see Propagule Selection) produced satisfactory residual nesting cover for ring-necked pheasants (*Phasianus colchicus*) on upland sites in Wisconsin (Frank and Woehler 1969). With other tall grasses, switchgrass furnishes nesting and escape cover for the greater prairie-chicken (*Tympanuchus cupido*) in northeastern Colorado (Evans and Gilbert 1969) and for the lesser prairie-chicken (*T. pallidicinctus*) in Texas (Coastal Zone Resources Division 1978) and southeastern Colorado (Hoffman 1963). In Oklahoma both species of prairie-chicken use tall herbaceous vegetation for roosting cover (Jones 1963).

Comparative production and crude protein content of switchgrass strains were tested at the Colorado Agricultural Experiment Station; results are presented in Table 3. Three strains each produced between 1500 and 2000 lb of forage per acre, and protein content compared favorably with other commonly used grasses.

## ESTABLISHMENT

### Site Selection

Areas recommended for planting switchgrass include idle land; fencerows; gullies; borrow pits; roadside depressions; and borders, corners, and islands that cannot be grazed or mowed. Tall grass mixtures containing switchgrass can be used to improve wildlife habitat on sites such as rangeland roads and pipelines (Baumgartner 1945), sandhill blowouts, abandoned croplands, old

Table 2. Food and cover values\* of switchgrass for wildlife species in 4 Western States (Dittberner and Olson 1983)

<u>Species</u>	<u>Utah</u>	<u>Wyoming</u>	<u>Montana</u>	<u>North Dakota</u>
<u>Elk</u>				
Food	P			
Cover	P	P		
<u>Mule deer</u>				
Food	P	F		P
Cover	P	P		P
<u>White-tailed deer</u>				
Food		F		P
Cover		F		F
<u>Pronghorn</u>				
Food	F	P		P
Cover	P	P		P
<u>Upland game birds</u>				
Food	G	G	P	F
Cover	F	G	P	G
<u>Waterfowl</u>				
Food	G	G		
Cover	F	G		
<u>Small nongame birds</u>				
Food	G	G	P	
Cover	F	G	P	G
<u>Small mammals</u>				
Food	G	G	P	
Cover	G	G	P	

\* P = poor, F = fair, G = good.

Table 3. Forage yield and crude protein of 3 strains of switchgrass tested in Colorado (Sims and Everson 1969)

<u>Strain</u>	<u>Average Forage Yield (lb/acre)</u>	<u>Average Crude Protein (percent)</u>
Caddo	1934	7.5
Grenville	1408	8.9
Nebraska 28	1514	7.8
Average	1619	8.1

homesteads, and unused corrals (Everson et al. 1965). Dambach (1945) suggested that even a 4-ft-long fenceline planting can be beneficial to wildlife, and Yeatter (1963) encouraged the development of strips along ditches, lanes, and fences to improve prairie-chicken habitat. Windbreaks incorporating switchgrass can provide needed wildlife cover if placed in open fields subject to strong winds.

#### Site Preparation

Plot design. Cover plantings for upland game birds should be large enough to permit escape from predators and should be located near feeding and courtship areas. Seeding both sides of fences, roads, and waterways affords more protection than seeding only one side. Schwendiman (1957) reported that upland game birds used row plantings more than solid stands; therefore, switchgrass is recommended for use in 2-row windbreaks (Johnson and Anderson 1980) and row plantings that can be treated as cultivated crops (McIlvain and Shoop 1960b).

Plots should generally be elongated, at least 2 rows in width, and planted on the contour. Recommended plot size varies from less than 1 acre to greater than 10 acres, but several plots of 1 acre or less are preferred to large plots (Olson 1977). Potential rangeland seeding areas tend to be larger and more nearly rectangular, whereas plots on homestead and corral sites are smaller and somewhat irregular in shape. Gullies and waterways usually fit an elongated, irregular pattern (Stoddard 1946).

Mechanical treatment. A seedbed free of weeds is required for successful establishment of switchgrass stands. Larger sites should be plowed, but disk-ing may be omitted if plots are seeded with press and corrugated drills. Rototillers can be used to prepare fencerows, roadsides, and narrow strip plantings, and rotaseeders can be employed in areas of sparse weedy competition (Joselyn and Tate 1972). The sides of blowouts, gullies, and waterways can be shaped with a dozer. Gully banks should be graded to an angle no greater than the soil's angle of repose, and dams of rocks, brush, and logs should be built across the gully. Mine soils of coal fields should be graded, ripped or chiseled, backfilled with topsoil, and retilled with a heavy-duty disk harrow or chisel plow; rough, steep slopes may be amenable only to scarification with a dozer (Vogel 1981).



Soil amendments. Fertilizers for range and pasture seedings in the Great Plains and Western States are usually not cost effective (McIlvain and Shoop 1960b, Atkins and Smith 1967, Williamson et al. 1975, Launchbaugh and Owensby 1978). Severely eroded topsoils and sterile subsoils, particularly in the East, should be tested to determine fertilizer needs. Most of the Midwestern and Eastern coal spoils need lime and phosphates incorporated into the soil before seeding (Vogel 1981).

The use of stubble mulch can greatly enhance stand establishment. Except in the eastern prairie, a mulch crop of sorghum (*Sorghum vulgare*) or sudan-grass (*S. sudanense*) can be grown onsite the year before planting switchgrass and plowed under before site preparation. To prevent competitive volunteer crops, grass varieties that have minimal hard seed should be used (Launchbaugh and Owensby 1970). Some stubble can be left on the surface to aid erosion control.

#### Propagule Selection

Switchgrass stands are usually established with seeds; however, seedlings, sod, and seed-bearing hay are also used. Seedling and sod transplanting is more expensive than seeding, but transplants produce more vigorous stands during the first growing season.

Cultivars. Recognized cultivars of switchgrass are the following: Blackwell (released from Kansas); Caddo (Oklahoma); Grenville, a high-elevation variety (New Mexico); Kanlow, a coarse, upright bunchgrass (Kansas); Nebraska 28 and Pathfinder (Nebraska); Summer, a South Dakota release of Nebraska origin; Alamo (Texas); and PM-SD-149, currently being tested (South Dakota) (Hanson 1972, Thornburg 1982, Haferkamp and Copeland 1984). Each strain is winter hardy and phenologically functional within 100 miles of its origin.

Seeds. Seeds are readily available from commercial sources. Good quality seed should test 95% purity, 70% germination, and 66% pure live seed; a pound should consist of approximately 389,000 seeds (Atkins and Smith 1967).

Seed may be harvested with a combine while plants are still standing (Atkins and Smith 1967) or cut with a binder, dried, and then combined (Hoover et al. 1947). A fanning mill can be used for cleaning seeds; however, Wasser (1982) recommended hammermilling at 800 rpm and recleaning in a fanning mill fitted with 1/14 and 1/22 upper and lower screens. Seeds should be stored dry

at 5° C (Environmental Laboratory 1978). Fulbright et al. (1982) provide additional references and information on seed and culture.

Germination and vigor. Switchgrass seeds germinate well for 3 to 8 years after harvest (Wolf 1951, McWilliams 1955). In laboratory tests, germination occurs in 28 days; however, scarification or stratification may be necessary to produce rapid germination in the field (Sautter 1962, Association of Official Seed Analysts 1978, Wasser 1982). Because seeds have relatively high dormancy, germination is more efficient when 1-year-old seeds are used (Robocker et al. 1953).

Seedlings show fair to medium vigor, with improvement in the newer varieties. At least 2 growing seasons are required for stands to become fully established on drier sites (Atkins and Smith 1967, Vogel 1981); however, it is possible to establish a stand during the first growing season if irrigation or sufficient rainfall is available (W. G. Vogel, pers. commun., 1979).

#### Planting Methods

Time of seeding. Early spring is the best time for seeding, but the optimal period varies with latitude. Wasser (1982) recommended planting from March through April in the southern Great Plains and from April through May in the northern Great Plains. Ideally, seeds should be sown just prior to the 2 months that have temperatures and moisture conditions most favorable for rapid germination.

Seeding. Drilling, broadcasting, and spreading hay that contains seed are the usual methods of seeding switchgrass. To seed solid stands on clean, level land, drilling can be done with a standard plains grass drill equipped with double-disk furrow openers, depth bands, and separate seed hoppers. Presswheels for firming the seedbed are recommended and may be essential. Widely spaced (3 to 4 ft) row seedings can be made by blocking alternate seed drops of a grass drill or by using a cotton or corn planter. On erosive sites, stands are more successful if seeded in mowed or grazed stubble mulch (Cornelius 1950, McIlvain and Shoop 1960b, Atkins and Smith 1967, Launchbaugh and Owensby 1978). A rotaseeder can be used for small strip plantings (Joselyn and Tate 1972).

Optimal depth of seeding is from 1/4 to 3/4 in. (McWilliams 1955). Recommended seeding rates vary from 2 lb of seed per acre for widely spaced rows to 12 to 15 lb per acre for solid drilled and broadcast stands in Eastern

coal field zones (McIlvain and Shoop 1960b, Merkel and Herbel 1973, Vogel 1981). If the seeding rate is too heavy, stand development may be delayed by excessive seedling competition (Vogel 1981). Lower seeding rates will likely result in taller plants and increased seed production, which benefits wildlife (McWilliams 1955).

Broadcasting hay that contains mature switchgrass seed may be the most effective method of seeding extremely erosive sites, such as blowouts. From 1500 to 2000 lb of hay per acre can be spread on the site and anchored with manure or lightly disked into the soil (Everson et al. 1965, Atkins and Smith 1967). This may also be the only feasible method to use on rough mine soils and loose sandy soils of the East (Vogel 1981).

Transplanting. Sprigs or sod should be transplanted in early spring, when soils are moist but not wet. Sprigs can be set in 3-ft-wide rows; they should be fertilized initially and several weeks after the first signs of growth (Coastal Zone Resources Division 1978). When transplanting sod, pieces 4 x 5 x 5 in. should be randomly removed to minimize soil erosion and should be kept damp until planted. Transplants can be stacked on wooden boards or set into crates for transporting; however, they should be placed in strong bags if planting will be delayed for more than 24 hours. Sod pieces can be firmed into holes dug with a posthole digger or placed in contour furrows with the crowns at ground level (1 to 2 in. lower in dry areas). During the first growing season, plants may require weekly irrigation if soil moisture is inadequate (Cassady 1937, Aldon 1978).

Planting mixtures. Grass and grass-legume mixtures commonly include from 10% to 25% switchgrass for rangeland restoration and pasture seeding on mine spoils in coal field regions (Hull et al. 1958; McIlvain and Shoop 1960a,b; Atkins and Smith 1967; Vogel 1981). Snyder (1974) suggested adding it to mixtures of cool-season grasses and legumes used in roadside seedings for pheasant nesting in northeastern Colorado. Species recommended for planting with switchgrass are listed in Table 4.

#### MAINTENANCE

Native grass mixtures similar to prairie species composition require little maintenance after establishment. These mixtures are tolerant of fire, and occasional late spring burning will stimulate early new growth and increased seedstalk production (Vogel 1981).

Table 4. Species recommended for planting with switchgrass  
in selected areas of the United States

Species	Eastern Colorado Sandhills*	Southern Great Plains**	Midwestern and Eastern Coalmine Spoils†
<u>Grasses</u>			
Bluestems (mixed) ( <i>Andropogon</i> spp.)		X	
Big bluestem ( <i>Andropogon gerardii</i> )		X	X
Little bluestem ( <i>Schizachyrium scoparium</i> )		X	X
Sand bluestem ( <i>Andropogon hallii</i> )	X	X	
Buffalograss ( <i>Buchloe dactyloides</i> )		X	
Blue grama ( <i>Bouteloua gracilis</i> )		X	
Sideoats grama ( <i>Bouteloua curtipendula</i> )	X	X	X
Indiangrass ( <i>Sorghastrum nutans</i> )		X	X
Sand lovegrass ( <i>Eragrostis trichodes</i> )	X	X	
Western wheatgrass ( <i>Agropyron smithii</i> )		X	
<u>Forbs</u>			
Alfalfa ( <i>Medicago sativa</i> )	X		
Sweetclover ( <i>Melilotus</i> spp.)	X		
Illinois bundle flower ( <i>Desmanthus illinoensis</i> )			X
Birdsfoot trefoil ( <i>Lotus corniculatus</i> )			X

\* A mixture with alfalfa and lovegrass is expensive for sandhills (Hull et al. 1958).

\*\* McIlvain and Shoop 1960a, Allred and Nixon 1955.

† Vogel 1981.

Annual application of fertilizer is needed to maintain high production in dense switchgrass stands. McIlvain and Shoop (1960b) recommended 40 lb of nitrogen per acre on good dryland sites, with an additional 20 lb of phosphorus per acre on infertile soils; side dressings of both may be necessary in the southern Great Plains (Atkins and Smith 1967). Williamson et al. (1975) suggested nitrogen rates of 40 to 50 lb, 50 to 75 lb, and 100 lb per acre for pure stands of grasses in western, east-central, and eastern South Dakota, respectively. When grasses are irrigated for hay production, up to 160 lb of nitrogen per acre may be needed and should be divided equally between an application in spring and one after the first mowing (Williamson et al. 1975). Soils should be tested to determine the phosphorus and potassium requirements of grass-legume mixtures on both dryland and irrigated sites.

Methods of weed control in seedling stands include the use of mulch crops, cultivation, spraying, mowing, and grazing. Broad-leaved weeds in seeded stands can be sprayed with 1/2 lb of 2,4-D ester per acre, and most weeds can be eliminated by applications of 2 to 3 lb of atrazine per acre. Seedlings should not be sprayed before reaching the 3-leaf stage.

#### CAUTIONS AND LIMITATIONS

Because forbs may be killed by herbicides, mixed stands of grasses and forbs should be mowed or grazed to control weeds (McIlvain and Shoop 1960b, Perry and Stubbendieck 1976, Derscheid et al. 1977). Launchbaugh and Owensby (1978) reported that grazing can be as effective as mowing or chemical application and is less expensive. Moderate continuous summer grazing or an early rotation system is recommended for good-condition ranges, whereas deferred or rotation grazing is prescribed for seeded pastures and poor-condition ranges (Wasser 1982). Grazing and mowing of strip plantings should also be deferred during nesting season (Olson 1977). New growth should be at least 6 in. tall before stands are grazed, and an 8-in. stubble should be maintained for continued seed production (McIlvain and Shoop 1960b, Derscheid et al. 1977).

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